DIGITAL RENOVATION OF THE GEOLOGIC MAP OF THE NEAR SIDE OF THE MOON. C. M. Fortezzo and T. M. Hare, United States Geologic Survey Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, Arizona, cfortezzo@usgs.gov.

Introduction: In support of a NASA Planetary Geology and Geophysics funded project to digitize existing lunar paper maps and the increasing emphasis on lunar studies from recent orbital data returns, we have renovated the digital version of the lunar near side geologic map [1]. The renovations used new topographic data and image mosaics to adjust the original linework and adjust the mapped area to the current ULCN2005 control network [2].

This map is not a reinterpretation of the original geologic units or relationships, but a spatial adjustment to make the original work more compatible with current digital datasets. This increased compatibility allows these maps to be compared and utilized with ongoing and future lunar mapping projects. This work represents the beginning of a project aimed at digitizing the original maps that made up the global view of the Moon [1, 3-7].

Background: The 1:5M map was a synthesis of 36 1:1M maps produced from Earth-based telescopic observations and Lunar Orbiter imagery [1]. The purpose of the synthesis was to produce a coherent and consistent near side time-stratigraphy. The base image for 1:5M map was generated by the United States Air Force Aeronautical Chart and Information Center in 1966 in an orthographic projection. The irregular boundary for the map area follows the boundaries for the 36 1:1M maps and narrows in steps as it approaches the poles.

The 1:5M map delineated 43 geologic units that are broken down into the following major groupings: dark materials (5 units), circumbasin materials (7 units), crater materials (20 units), and terra plain, plateau, and dome materials (11 units) and spanning the pre-Imbrium to the Copernican System. The only linear representations on the map are geologic contacts and basin rings. There was no distinction between contact types (e.g., certain, approximate, buried, etc.) used in the original 1:5M map. The map also included the accepted nomenclature of the time for features of interest.

The map was digitized the first time by the USGS in 2000 by tracing units on a scanned version of the map. These original digital files were created in the orthographic projection in ArcInfo Workstation, and reprojected into a simple cylindrical projection for compatibility with the global datasets. It was not possible to salvage these original files because they were registered to a hand-tied airbrushed mosaic based on an older control network. The renovation described herein has allowed us to correct flaws in the original digital product, including improving consistency in vertex spacing and adding (where appropriate) a level of vector smoothing to remove redundant vertices.

Datasets: Four orbital datasets were used to renovate the lunar near-side map (listed in order of utility): Lunar Orbiter global mosaic (~63 m/pix), Kaguya Digital Terrain Model (~2 km/pix), Clementine UV-VIS (100 m/pix), and the Clementine Mineral Ratio (200 m/pix). The Lunar Orbiter global mosaic provides visible imagery of the lunar surface allowing for distinct delineation of the morphologic and geologic relationships. The Kaguya Digital terrain Model provided a rough topography allowing for delineation of features that were less prominent in the Lunar Orbiter mosaic. The Clementine UV-VIS provided a tool for identifying the mare geologic units which make up 40% of the total map area [1]. The Clementine Mineral Ratio map was used sparingly but was helpful in some locations where it was necessary to delineate ejecta blankets.

Methodology: The current renovation of the digital map (Fig. 1) adhered to strict guidelines for vector generation and used recent datasets to spatially adjust the location of the geology and linework. This adjustment did not change the original geologic framework but sought to update the locations of the contacts and geology. These adjustments resulted in the omission of some discrete units by connecting areas that were previously mapped as isolated portions and, vice versa, isolated previously grouped units. The sole new addition to the map was the use of an approximate contact to indicate areas where (a) the geologic relationships were unclear to the digital author and (b) where the datasets did not provide adequate information for the interpretations of the original map.

The data sets discussed above were used in combination with ESRI's ArcMap Geographic Information System (GIS) software, to draw vectors on the Lunar Orbiter global mosaic. The vectors were drawn with a consistent vertex spacing of ~3 km at 1:1.5M scale, and were smoothed using a maximum allowable offset tolerance of ~16 km. The adjustments and the adherence to these guidelines resulted in a product that increased the feature location accuracy at the 1:5M scale and makes the product more cartographically appealing.

Generating the polygons from the contact linework was an iterative process that involved making certain that all polygons were accounted for, and making changes to the contacts as needed. Once all geology polygons were built, the contacts were smoothed and topology errors caused by the smoothing process were fixed by assigning topology rules in ArcMap. Geology polygons were generated from the smoothed contacts and attributed using the thorough geologic attributes from the original digital files generated in 2000. The geologic attributes from the original digitization of the map were used because the work only needed slight spatial adjustments and were robust in their descriptions. These attributes were held in point data and included the unit symbol, unit name, major grouping designation, epoch of lunar time, and a brief description of the unit. These data were merged into the renovated geologic map when the remapped polygons were generated. Because of the lumping/splitting of units and the spatial adjustment, it was necessary to quality check each geology polygon and its associated attribute to ensure that the two features matched. Basin rings were digitized once editing of the contacts and geology was finished.

No nomenclature is included on the map because of the availability of digital nomenclature provided by the U.S. Geological Survey's IAU Planetary Names website (http://planetarynames.wr.usgs.gov). This site will allow users of the map to choose which features are displayed digitally and in paper copies they generate.

Results: The renovated lunar near side geologic map provides the community with a means to digitally view and analyze the data from the original map. The ability of GIS to analyze data reinvigorates the 40 year-old product and makes it a viable product for a new generation of planetary scientists in a paradigm of increasing reliance on digital resources. Additionally, with a new influx of lunar data, it is important to preserve and extend the capabilities of this useful heritage map.

Future Work: This project will continue to digitally renovate the 6 original lunar geologic maps. However, with recent emphasis on the poles and the permanently shadowed craters, increases the priority of the two polar maps. The polar maps will be completed in the next year, with the focus shifting the year after to the far side of the Moon. Once all of the maps are completed, the feasibility of merging the maps will be assessed.

References: [1] Wilhelms, D.E. and J.F. MacCauley (1971) *Map I-703*. *[2]* Archinal, B. et al. (2006), *Open-File Report 2006-1367*. [3] Wilhelms, D.E., et al. (1979) *Map I-1162*. [4] Lucchitta, B.K. (1978) *Map I-1062*. [5] Wilhelms, D.E. and F. El-Baz (1977) *Map I-948*. [6] Stuart-Alexander, D.E. (1978) *Map I-1047*. [7] Scott, D.H. et al. (1977) *Map I-1034*.

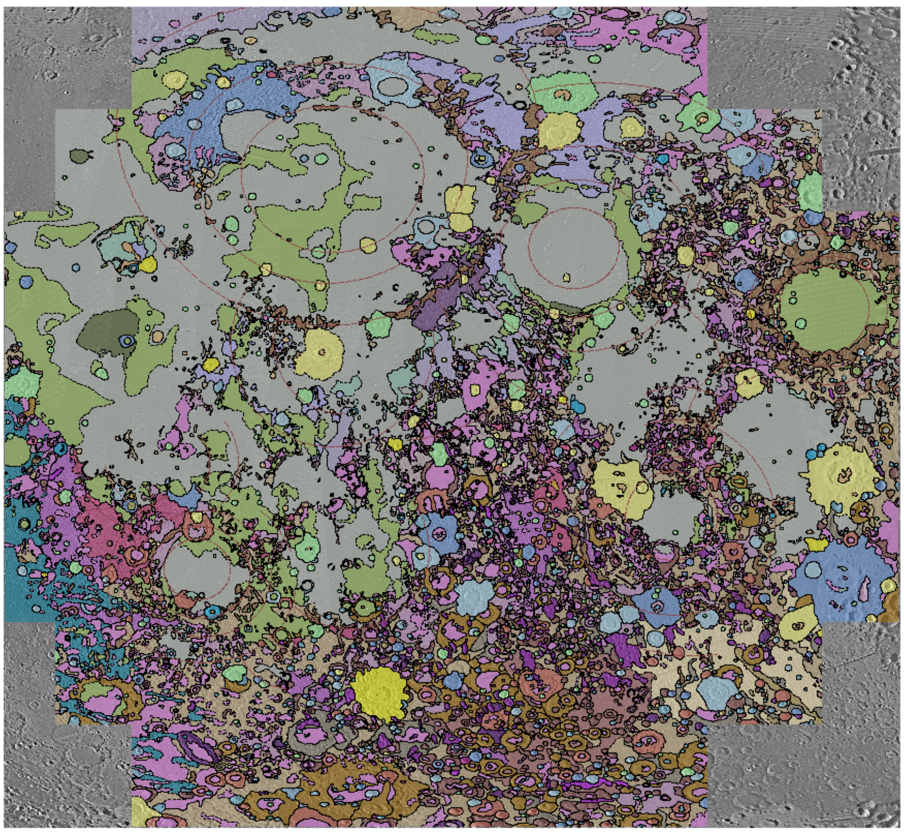

Figure 1: Renovated geologic map of the near side of the Moon. The basemap is the Lunar Orbiter mosaic. The geology polygons are set to a 50% transparency and the colors are an attempted match to the original color scheme. The black lines are the certain and approximate contacts and the brown lines indicate the basin rings. The map is in simple cylindrical and the map extends from 64ºN to 64ºS and 70ºW to 70ºE.